

Appl. No. 09/937,858
Amdt. dated July 5, 2005
Reply to Office action of April 5, 2005

In the Claims:

Claims 1, 8 and 11 are amended herein. Claim 5 is canceled.
New claims 18 and 19 are added. The remaining claims are not
amended in this response.

1. (previously presented) An image forming device that
forms an image on a print paper in an ink jet recording method
with at least one head, comprising:

main scanning direction moving means for moving a carriage
in a main scanning direction, said carriage having said at least
one head mounted thereon;

paper conveying means for conveying the print paper in a
sub-scanning direction;

pattern printing means for printing, with said at least one
head, a test pattern including predetermined pattern elements;

pattern detecting means, mounted on said carriage, for
detecting the pattern elements of the test pattern printed on the
print paper by said printing means;

binary conversion means for binarizing an output of
said pattern detecting means;

position detecting means for detecting a position of
the carriage in said main scanning direction; and

calculating means for moving said carriage to detect
the pattern elements of the test pattern with said pattern

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detecting means, for detecting a print position of the pattern elements based on a detection result of said position detecting means when a rising and/or falling edge of a binary signal obtained by said binary conversion means is generated, and for calculating a mounting deviation amount of each head in said main scanning direction,

wherein said position detecting means comprises low-resolution position detecting means based on a linear scale provided on a movement path of said carriage and high-resolution position detecting means for detecting a position more than twice as finely as a minimum unit determined by a resolution of said low-resolution position detecting means,

wherein said low-resolution position detecting means comprises a counter for counting a timing signal based on said linear scale to determine a low-resolution position of said carriage at a time when said a rising and/or falling edge of a binary signal obtained by said binary conversion means is detected, and wherein said high-resolution position detecting means comprises a timer which is initialized by said timing signal and measures a time with a predetermined clock signal to determine a high-resolution position of said carriage within a unit interval determined by a resolution of said linear scale at a time when said a rising and/or falling edge of a binary signal obtained by said binary conversion means is detected, and

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wherein a count value of said counter and a measured value of said timer are combined with each other to precisely define the position of the pattern element detected by said pattern detecting means, and said position of the pattern element is compared with a print target position of said pattern element to obtain a mounting deviation amount of the head that printed said pattern element.

2. (previously presented) The image forming device according to claim 1 wherein, for each head, said test pattern is at least one vertical bar extending in the sub-scanning direction substantially perpendicular to said main scanning direction.

3. (previously presented) The image forming device according to claim 1, wherein said test pattern includes, for each head and as a pattern element, at least one horizontal bar extending substantially in parallel with said main scanning direction, further comprising:

conveyance amount detecting means for detecting a conveyance amount of the print paper in the sub-scanning direction substantially perpendicular to said main scanning direction; and

measuring means for measuring the conveyance amount equal to or smaller than a minimum unit determined by a resolution of said conveyance amount detecting means,

wherein said calculating means moves the print paper, on which the test pattern is printed, with the use of said paper

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conveying means with respect to the carriage to detect the pattern elements of the test pattern with said pattern detecting means, detects the print position of the pattern elements based on the detection results of said conveyance amount detecting means and said measuring means when a rising and/or falling edge of the binary signal obtained by said binary conversion means is generated, and calculates an amount of mounting deviation of each head in said sub-scanning direction based on the print position of the pattern elements printed by each head.

4. (previously presented) The image forming device according to claim 1 wherein said pattern detecting means is a reflective sensor comprising a light emitting element and a light receiving element.

5. (canceled)

6. (previously presented) An image forming device that forms an image on a print paper in an ink jet recording method with a plurality of heads, comprising:

main scanning direction moving means for moving a carriage in a main scanning direction, said carriage having said plurality of heads mounted thereon;

paper conveying means for conveying the print paper in a sub-scanning direction;

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pattern printing means for printing, with at least one head,
a test pattern including predetermined pattern elements;

pattern detecting means, mounted on said carriage, for
detecting the pattern elements of the test pattern printed on the
print paper by said printing means;

binary conversion means for binarizing an output of said
pattern detecting means;

position detecting means for detecting a position of the
carriage in said main scanning direction; and

calculating means for moving said carriage to detect the
pattern elements of the test pattern with said pattern detecting
means, for detecting a print position of the pattern elements
based on a detection result of said position detecting means when
a rising and/or falling edge of a binary signal obtained by said
binary conversion means is generated, and for calculating a
mounting deviation amount of each head in said main scanning
direction,

wherein said position detecting means comprises low-
resolution position detecting means based on a linear scale
provided on a movement path of said carriage and high-resolution
position detecting means for detecting a position more finely
than a minimum unit determined by a resolution of said low-
resolution position detecting means such that said low-resolution
position detecting means and said high-resolution position

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detection means are combined with each other to precisely detect the positions of the pattern elements,

wherein, for each head, said test pattern is at least one vertical bar extending in the sub-scanning direction substantially perpendicular to said main scanning direction, and

wherein said pattern printing means causes each of different portions of a single head to print a plurality of dots sequentially in a plurality of passes, said plurality of dots constituting a portion of said vertical bar.

7. (previously presented) The image forming device according to claim 1 wherein said calculating means uses said pattern detecting means to detect the vertical bar in at least two positions in a longitudinal direction of said vertical bar to obtain a print position of said vertical bar based on an average value of the detected results.

8. (previously presented) The image forming device according to claim 1, further comprising:

means for measuring a unit time interval of said linear scale at a time said pattern elements are detected; and

means for correcting a measured value of said timer based on the measured value and a theoretical value of said unit time interval.

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9. (previously presented) An image forming device that forms an image on a print paper in an ink jet recording method with a plurality of heads, comprising:

main scanning direction moving means for moving a carriage in a main scanning direction, said carriage having said plurality of heads mounted thereon;

paper conveying means for conveying the print paper in a sub-scanning direction;

pattern printing means for printing, with at least one head, a test pattern including predetermined pattern elements;

pattern detecting means, mounted on said carriage, for detecting the pattern elements of the test pattern printed on the print paper by said printing means;

binary conversion means for binarizing an output of said pattern detecting means;

position detecting means for detecting a position of the carriage in said main scanning direction; and

calculating means for moving said carriage to detect the pattern elements of the test pattern with said pattern detecting means, for detecting a print position of the pattern elements based on a detection result of said position detecting means when a rising and/or falling edge of a binary signal obtained by said binary conversion means is generated, and for calculating a mounting deviation amount of each head in said main scanning direction,

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wherein, for each head, said test pattern includes as a pattern element at least one vertical bar extending in the sub-scanning direction substantially perpendicular to said main scanning direction, and

wherein said pattern printing means divides said vertical bar into a plurality of portions and causes each of different portions of a single head to print a plurality of dots sequentially in a plurality of passes, said plurality of dots constituting a portion of said vertical bar.

10. (previously presented) The image forming device according to claim 1 wherein, based on both edges of an obtained pattern element, said calculating means calculates a center position of a width of the pattern element.

11. (previously presented) A method, for use on an image forming device with a linear scale provided on a carriage movement path, for detecting a deviation between a print position actually printed on a print paper by a head and a print target position, said method comprising the steps of:

providing a timer for detecting a position within a unit interval determined by a resolution of said linear scale;_

printing a predetermined print element at the target position on the print paper by the head mounted on a carriage that scans in a main scanning direction;

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detecting said print element with a sensor mounted on said carriage while moving said carriage in a main scanning direction;

detecting a low-resolution position of said carriage based on said linear scale so as to determine a low-resolution position of said carriage at a time when the print element is detected by said sensor;

detecting a high-resolution position within the unit interval so as to determine a position of said carriage by combining said low-resolution position with a measured value of said timer at a time when the print element is detected by said sensor; and

obtaining the deviation between said high-resolution position and said print target position.

12. (original) The method according to claim 11, further comprising the step of correcting the high-resolution position within the unit interval, which was detected by said timer, based on an actual measurement value measured in a minimum unit interval of said linear scale and a theoretical value thereof.

13. (original) The image forming device according to claim 2 wherein said pattern detecting means is a reflective sensor comprising a light emitting element and a light receiving element.

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14. (original) The image forming device according to claim 3 wherein said pattern detecting means is a reflective sensor comprising a light emitting element and a light receiving element.

15. (canceled)

16. (previously presented) The image forming device according to claim 6 wherein said calculating means uses said pattern detecting means to detect the vertical bar in at least two positions in a longitudinal direction of said vertical bar to obtain a print position of said vertical bar based on an average value of the detected results.

17. (original) The image forming device according to claim 9 wherein, based on both edges of an obtained pattern element, said calculating means calculates a center position of a width of the pattern element.

18. (currently amended) A method for printing a test pattern including a predetermined pattern element on a print paper in an ink jet recording method with a head which includes vertically aligned recording elements, said predetermined pattern element having at least one vertical bar extending in a sub-scanning direction substantially perpendicular to a main scanning direction of said head, the method comprising the steps of:

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dividing said ~~pattern element~~ vertical bar to be printed
into a plurality of vertically aligned portions, each portion
being divided into N groups of dots; and

dividing said vertically aligned recording elements of said
head into N vertically aligned groups;

causing each n-th group of different portions said recording
elements of said head to print a plurality of dots sequentially
in a plurality of passes, said plurality of dots constituting a
portion of said pattern element n-th group of dots in each
portion of said vertical bar.

19. (previously presented) An image forming device that
forms an image on a print paper in an ink jet recording method
with at least one head, comprising:

main scanning direction moving means for moving a carriage
in a main scanning direction, said carriage having said at least
one head mounted thereon;

paper conveying means for conveying the print paper in a
sub-scanning direction;

pattern printing means for printing, with said at least one
head, a test pattern including predetermined pattern elements;

pattern detecting means, mounted on said carriage, for
detecting the pattern elements of the test pattern printed on the
print paper by said printing means;

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binary conversion means for binarizing an output of said
pattern detecting means;

position detecting means for detecting a position of the
carriage in said main scanning direction; and

means for moving said carriage to detect the pattern
elements of the test pattern with said pattern detecting means,
for detecting a print position of the pattern elements based on a
detection result of said position detecting means when a rising
and/or falling edge of a binary signal obtained by said binary
conversion means is generated,

wherein said position detecting means comprises low-
resolution position detecting means based on a linear scale
provided on a movement path of said carriage and high-resolution
position detecting means for detecting a position more than twice
as finely as a minimum unit determined by a resolution of said
low-resolution position detecting means,

wherein said low-resolution position detecting means
comprises a counter for counting a timing signal based on said
linear scale to determine a low-resolution position of said
carriage at a time when said a rising and/or falling edge of a
binary signal obtained by said binary conversion means is
detected, and wherein said high-resolution position detecting
means comprises a timer which is initialized by said timing
signal and measures a time with a predetermined clock signal to
determine a high-resolution position of said carriage within a

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unit interval determined by a resolution of said linear scale at a time when said a rising and/or falling edge of a binary signal obtained by said binary conversion means is detected, and

wherein a count value of said counter and a measured value of said timer are combined with each other to precisely define the position of the pattern element detected by said pattern detecting means.